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SPECIAL EDITION

# FROM

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#### SPECIAL EDITION

No subject is too mind-bending for Focus to tackle. You'll find 20 of the biggest ideas covered in this special issue

## WELCOME



FOR MOST OF recorded history, people have wondered what Earth would look like from up high. Socrates imagined something not a million miles away from a football: "The world, when viewed from above, resembles a ball sewn from twelve pieces of skin," he wrote around 2400 years ago.

It wasn't until 1946 that a camera at last captured views of Earth from space. It was mounted on a V-2 - a missile developed by the Germans in World War II and captured by the Americans. Launched from New Mexico, it took its picture from an altitude of 105km.

Before long, rockets were regularly carrying payloads into orbit and 1959 saw the first satellite image taken from space. A blurred, black-and-white picture of the Pacific Ocean, the Explorer 6 photo is a far cry from the colourful, high-resolution images you'll find in this special issue of Focus. From volcanoes, storms and rivers to cities and the remarkable extent of human impact, these images reveal a panoply of activity on Earth.

My favourite photos show Earth at night; whole continents that never

sleep. It's a reminder of iust how much of the globe we've covered with infrastructure in order to sustain intelligent life on our planet.

I often wonder what Farth will look like in 50 vears' time. Will even more of the planet's surface glow and twinkle with artificial light? Or will our desire to conserve energy plunge us into darkness once more? Only time will tell, but for now, sit back and enjoy what only astronauts have seen with their own eves: our home, whole.

#### Graham Southorn. Editor



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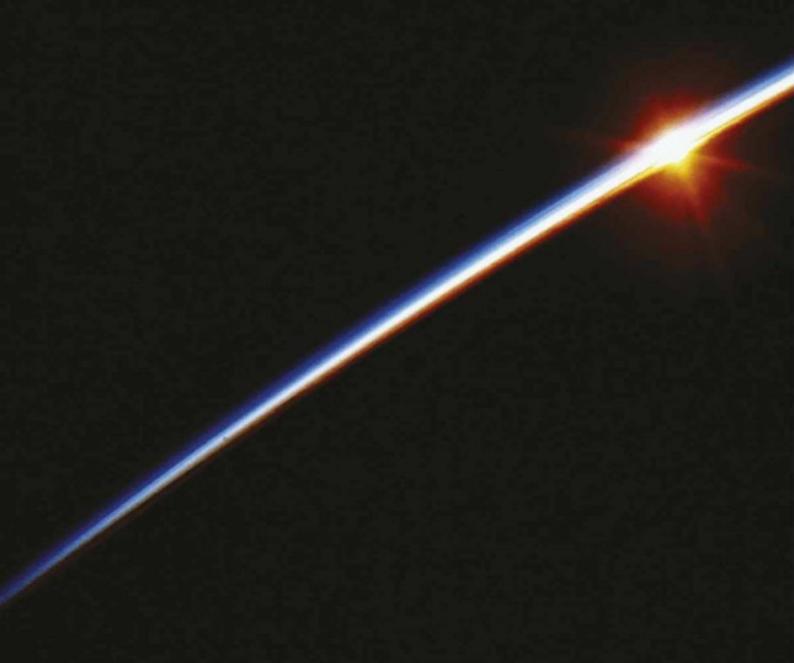


FRONT COVER PHOTO: ALAMY BACK COVER PHOTO: NASA

#### Sunrise

THIS DRAMATIC IMAGE of a sunsrise was taken by astronauts travelling at over 27,000km/h. At these speeds it only takes 90 minutes to orbit the planet, allowing them to see 16 sunrises and 16 sunsets every day.

PHOTO: KEVIN KELLEY/GETTY



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## INTRODUCTION



**TERRA** 



Apollo 8 astronaut Bill Anders took a photo of an 'Earthrise' from the Moon's orbit. As the first image showing how Earth appeared from deep space, it awakened a huge interest in photographing our planet.

In 1972, NASA launched the first

In 1972, NASA launched the first satellite that had the sole intent to monitor Earth's landmasses. It was called Landsat 1, and although it retired in 1978, the mission continues. Landsats 5, 7 and 8 all contribute images to *Earth From Space*. With the fleet's focus being on Earth's resources, their pictures provide great insight into the impact of human society.

N CHRISTMAS EVE 1968.

Satellites allow us to study and analyse many of Earth's previously unexplained processes. It's no coincidence that advances in weather prediction and natural disaster aversion all align with the rise of these orbiting devices. As technology has rocketed, so too has

the quality and variety of recordings that satellites take. The complex images are far more than just colour photos – the sensor onboard NASA's Suomi NPP satellite, for instance, measures electromagnetic radation. Orbiting between the poles, Suomi NPP provides data essential to understanding climate change.

Another of NASA's research missions is its TERRA satellite. It has five different image sensors, three of which provide spectacular pictures for this collection. The cameras each have different roles. One captures images of the surface, while another focuses on recording the atmosphere, clouds and land in a three-dimensional manner. Meanwhile a third instrument - the Moderate-Resolution Imaging Spectroradiometer (MODIS) - picks up atmospheric, land surface, and cryospheric features across the globe. There's another MODIS sensor on NASA's Aqua satellite. which observes Earth's water,



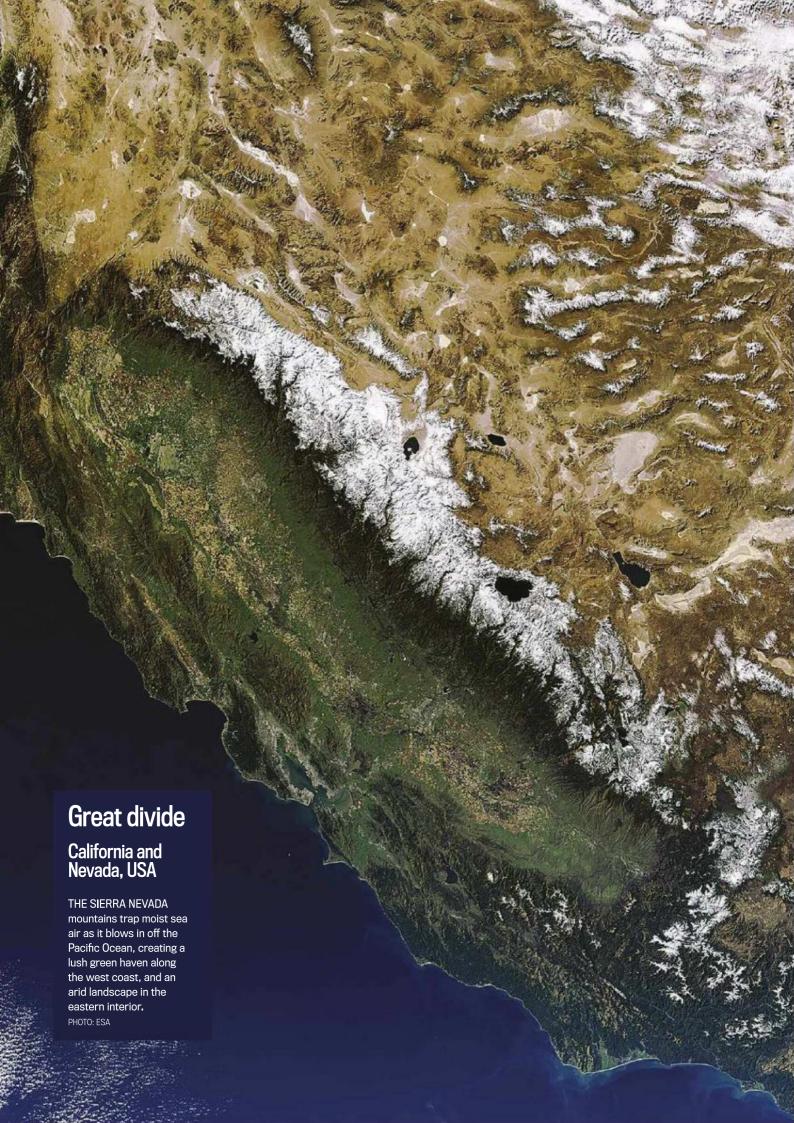


**International Space Station** 



#### The blue planet

▲ ONE OF THE first photos of the Earth in a single image. Shot by an Apollo 8 astronaut, it shows the planet at a distance of about 30,000km, with Antarctica at the top of the picture. PHOTO: NASA





monitoring seas, rivers, ice, clouds and even soil.

Photos from two of the planet's most cutting-edge imaging satellites also feature in this collection - GeoEye-1 and IKONOS. The high-resolution images from GeoEye-1 are the most detailed views of Earth that exist, while IKONOS captures multispectral images - showing data from beyond the visible light range - and black-and-white, or panchromatic, images.

With a rise in commercial satellites like GeoEye-1, the costs attached to these monitors have reduced, but still, the minimum price tag on a launch is £33m. So, when a satellite makes it into orbit, it is worth taking advantage of. Launched in 2000, NASA's Earth Observing-1 (EO-1) satellite was only intended for a year-long mission. But

the device proved so successful that it still runs today. EO-1 provides a wealth of pictures, from wide-angle land shots to hyperspectral images that scientists use to classify complex ecosystems.

It's not only satellites that watch uspermanently onboard the International Space Station (ISS) is a rotating crew of six astronauts, plus a host of Earthmonitoring instruments. Thanks to its low Earth orbit, the ISS looks down at a shallow angle, so its images provide a rare view of our world.

Those Apollo astronauts set off on their missions in the bold spirit of exploration. In the half century since, the ISS has taken shape, while thousands of satellites watch the globe. The spirit of Apollo lives on and, thanks to the amazing images in this special edition, we can all enjoy an astronaut's eye view.

#### The Colosseum

#### Rome, Italy

▲ THOUGH IT WAS built nearly 2100 years ago, this ancient amphitheatre stands tall. The 20,000m² site sits in the top left of this picture, surrounded by the modern city. PHOTO: DIGITALGLOBE/GETTY

#### Island paradise

#### The Bahamas

► THE VIVID BLUE waters of The Bahamas owe their practically luminous quality to the shallow depths of their seas. PHOTO: NASA/JEFF SCHMALTZ



#### Fort Bourtange The Netherlands

▲ THIS UNIQUE STAR fortress lies near the German border. The original structure was built in 1593 and served defensively for nearly two centuries. After a 25-year reconstruction project, the fort is now a museum. PHOTO: DIGITALGLOBE

#### Tornado track Massachusetts, USA

► ON 1 JUNE 2011, a 63km track of destruction - the pale-brown line that runs through the middle of this picture - was carved out by a single twister. At about 800m wide, the tornado ravaged residential and forest areas. PHOTO: NASA/JESSE ALLEN



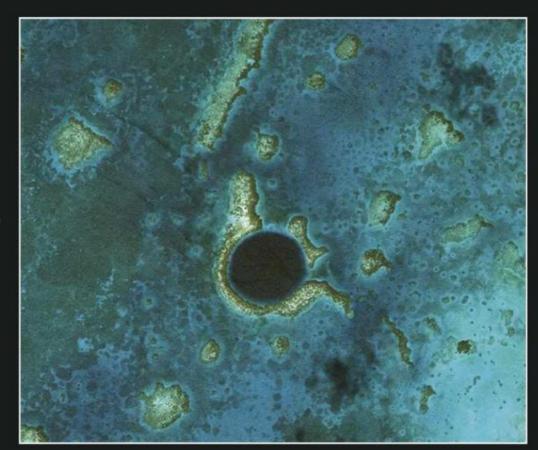






#### **Great Blue Hole**Belize

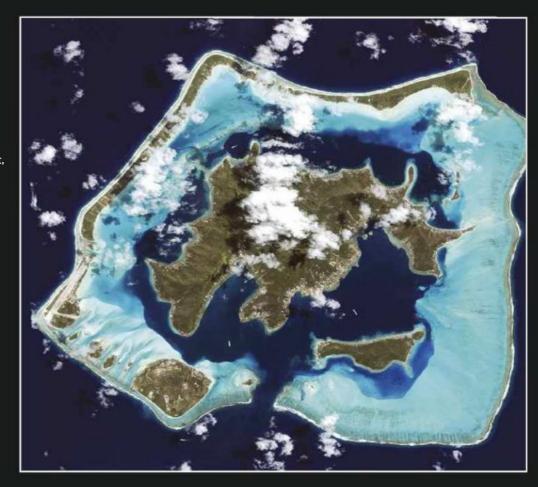
► THIS SPECTACULAR
underwater sinkhole is part of
the Belize Barrier Reef Reserve
System. A favourite among
scuba divers, the circular cave
is 300m wide and 124m deep.
In the last Ice Age, sea levels
were up to 120m lower than
today. Rain eroded the limestone
surface creating a cave. As the
ocean began to rise again, the
cave was flooded, resulting in
the Great Blue Hole.
PHOTO: DIGITALGLOBE



#### Bora Bora French Polynesia

► IN THE MIDDLE of the Pacific Ocean, surrounded by a lagoon and barrier reef, Bora Bora's volcanic land rises from the sea. After the volcano became extinct, the island started to subside. Coral grew, building a fringing reef around the island and creating the lagoon. As the island continued to sink, the barrier reef grew bigger.

PHOTO: DIGITALGLOBE/GETTY



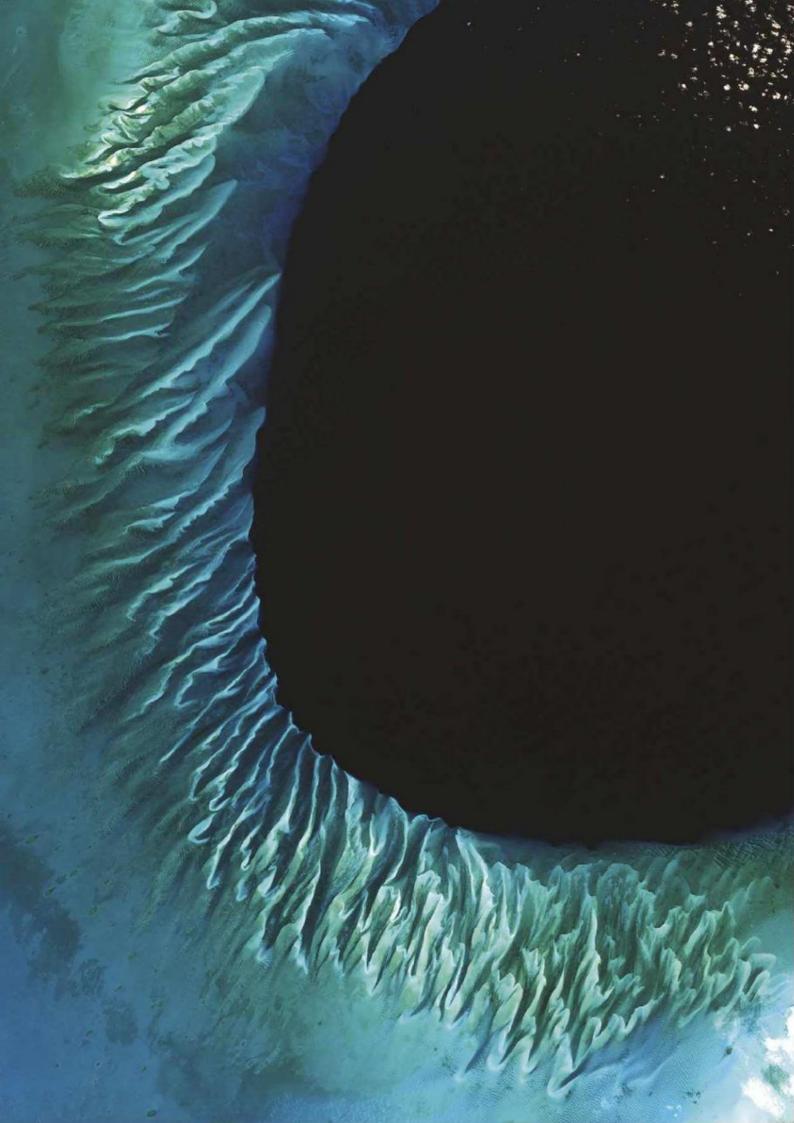












#### Sand and seaweed

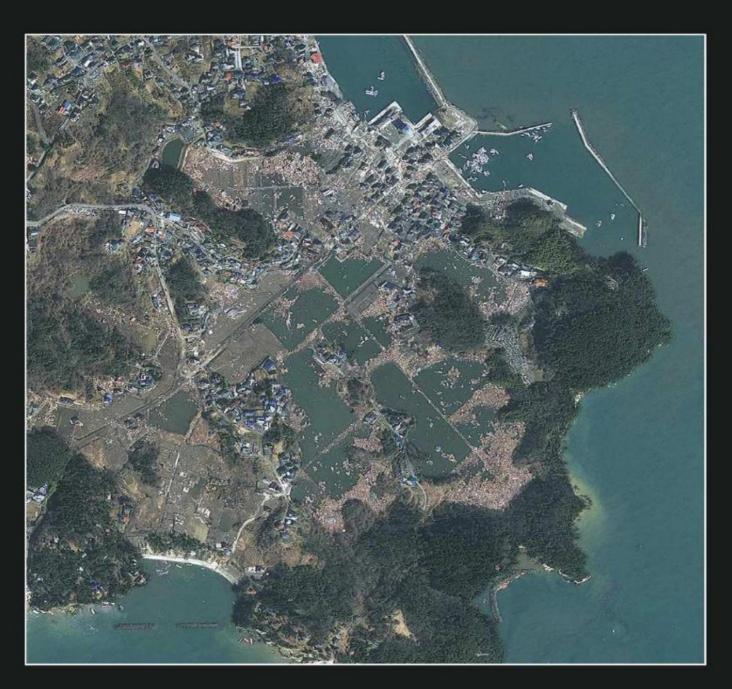
#### Bahamas

■ THE 'TONGUE OF The Ocean' is a deep. oceanic trench separating the islands of Andros and New Providence in The Bahamas. The blackness of the trench highlights the depth of the water in contrast with the turquoise sand and seaweed beds surrounding it. Ocean tides and currents have sculpted the sand into these mesmerising formations. PHOTO: NASA/SERGE ANDREFOUET

#### **Aftermath**

#### Sendai, Japan

▼ THE BEAUTY OF water is undeniable, but its inner beast is never far away. This image shows the devastation caused by the 9.0 magnitude earthquake on 11 March 2011, which triggered the destructive tsunami, claiming the lives of over 15,000 people. PHOTO: DIGITALGLOBE





### LANDWARKS There are many sites that define our landscape, both natural and human-made. While they're breathtaking from the ground, viewing them from above gives a whole new perspective Uluru Northern Territory, Australia RISING UP FROM the arid Australian Outback is Ayers Rock, or Uluru as it's known to the Aboriginal people. At 348m high and 3.6km long, it is claimed by many to be the largest rock in the world. At dawn and sunset, Ayers Rock appears to glow a deep red shade. WWW.SCIENCEFOCUS.COM 21

#### Giza Necropolis Near Cairo, Egypt

► THREE HUGE PYRAMIDS and the Great Sphinx make up the Giza Necropolis. The Great Pyramid (top), is the oldest of the Seven Wonders of the Ancient World. It was also the world's tallest human-made structure for over 3800 years.

PHOTO: DIGITALGLOBE/GETTY

#### Nazca Lines Ica region, Peru

▼ THEY WERE CREATED nearly 2000 years ago, yet the meaning behind these ancient designs remains unknown. The lines were made by removing the reddish pebbles that covered the surface to expose the pale ground below. PHOTO: NASA/GSFC/ASTER















#### Chichen Itza Yucatán, Mexico

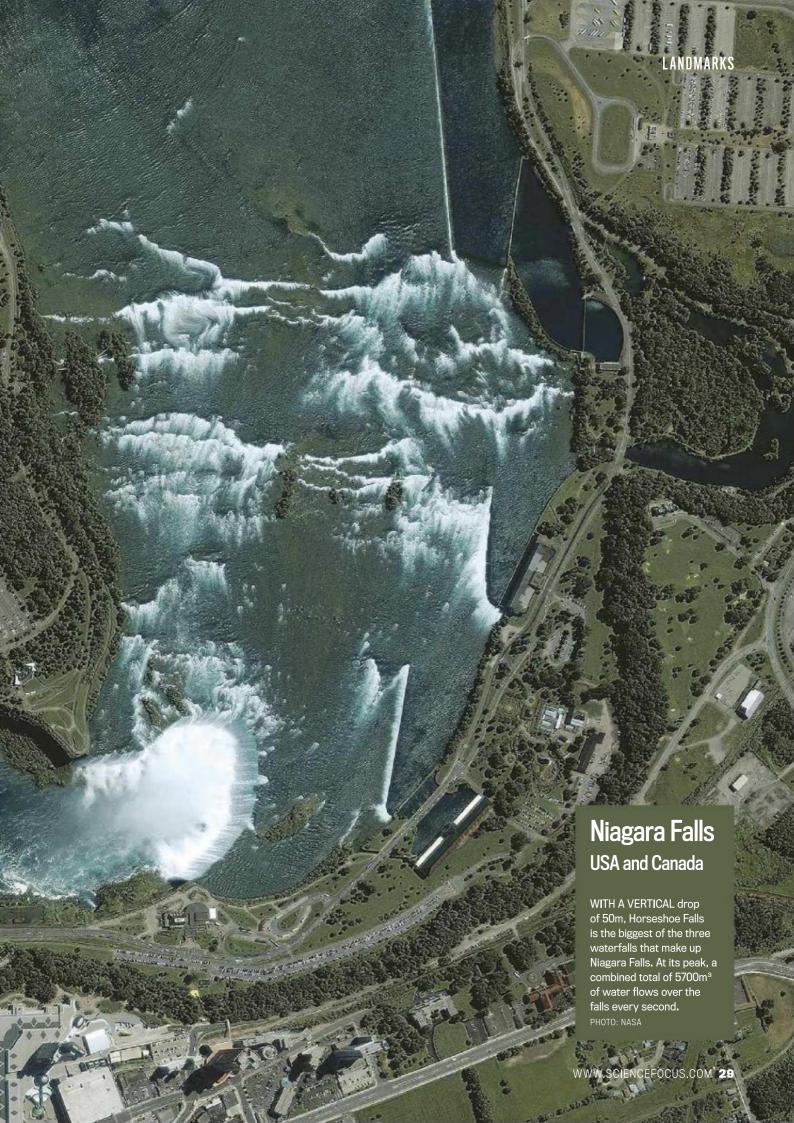
■ EL CASTILLO, THE towering, stepped pyramid, is the most famous of the Mayan city's ruins. It has 365 steps - 91 on each side plus one on the top - one for each day of the year. PHOTO: SATELLITE IMAGING CORP

#### Stonehenge Wiltshire, UK

▼ NOBODY KNOWS HOW or why Stonehenge was built. Using radiocarbon dating, archaeologists believe it dates from between 3000-2000 BC. PHOTO: SATELLITE IMAGING CORP







#### Burj Khalifa Dubai, UAE

► STANDING AT 829.8m, the Burj Khalifa is the tallest building in the world. It took over five years to build and cost just under \$1.5bn. It holds many world records, including the world's highest nightclub (144th floor).

PHOTO: DIGITALGLOBE/GETTY

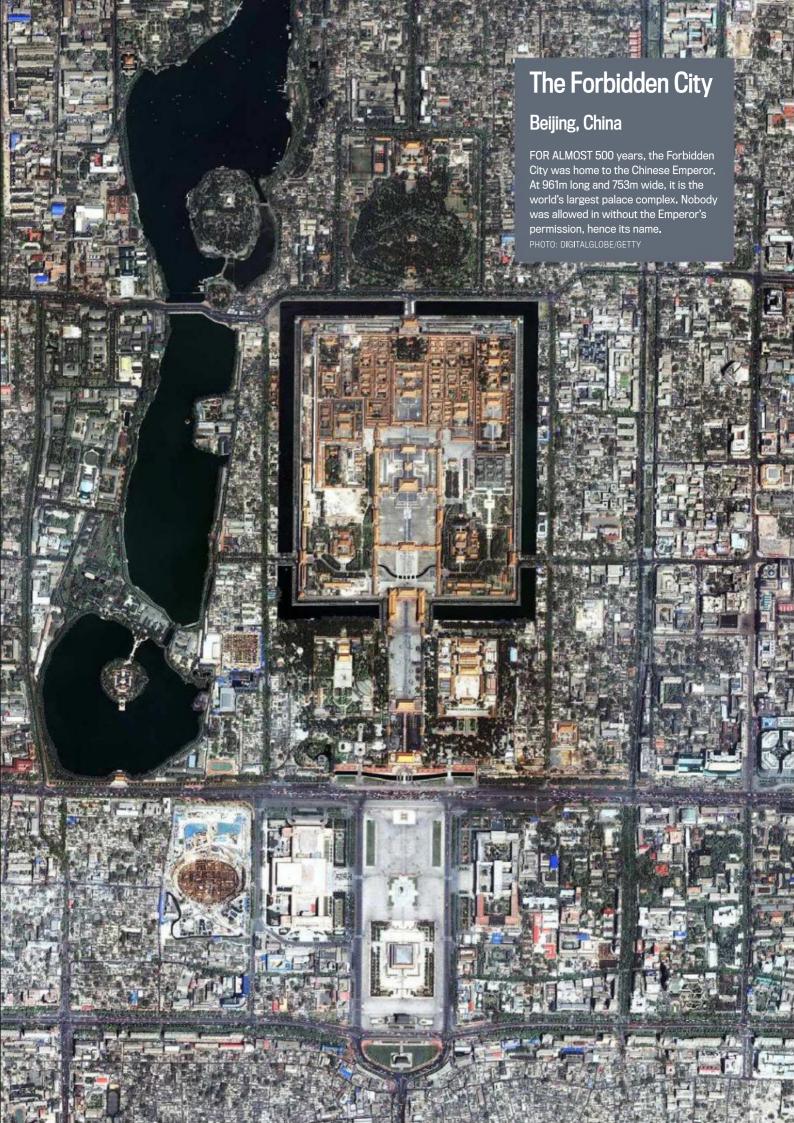


▼ ON A COLD winter's day, over one million people gather to witness the first inauguration of Barack Obama, the 44th President of the United States of America.

PHOTO: DIGITALGLOBE/GETTY









## THE GOLD EARTH The poles are melting faster than ever before, but now there's snow in the desert - both signs that our planet's climate is changing rapidly

#### Kenai Fjords Alaska, USA

BEAR GLACIER IS the largest of over 30 glaciers in Kenai Fjords. Once, ice would have covered the entire area. Since the 1940s, the glacier has been slowly retreating, which has created Strohn Lake at its base.

PHOTO: NASA/GEOEYE





#### **Beaufort Sea** Alaska, USA

 $\blacktriangledown$  THE IMAGE BELOW shows ice and snow off the coast of Alaska in May 2012. The bottom image is of the same area one month later. Ice retreat is common in June. However, this summer it was particularly rapid – up to  $150,000\,\text{km}^2$  of ice melted each day, double the normal rate.

PHOTO: NASA/JESSE ALLEN (LAADS)













# Petermann Glacier

### Greenland

■ ON 5 AUGUST 2010, a chunk of ice larger than Washington, DC, broke off the Petermann Glacier. It produced the largest iceberg in nearly 50 years and reduced the 70km long glacier by a quarter. PHOTO: NASA/JESSE ALLEN/ROBERT SIMMON (LAADS)

### Mountains Kyrgyzstan

▼ SNOW HIGHLIGHTS THE Tian Shan and Pamir Alay mountains that surround Lake Issyk-Kul. Mountains cover 95 per cent of this Central Asian country. PHOTO: NASA/GSFC/JEFF SCHMALTZ







# HUMAN IMPACT The planet has been evolving and changing since before humans existed. However, there can be no doubt of the effect that people have had on Earth's surface. Civilisation, farming and mining are just a few of the activities that have left their mark Gulf of Montijo **Panama** THE SAN PABLO river runs through Panama into the Gulf of Montijo. This image of the ecological transition zone shows the dramatic change in landscape from the protected wetlands surrounding the river to the farms and pastures further out. PHOTO: NASA/BURGESS HOWELL 42 EARTH FROM SPACE



## Deforestation 2000

### Rondônia, Brazil

► SINCE THE 1970s, the state of Rondônia has undergone rapid change. Initially, areas of the Amazon Rainforest were cleared for roads. Farmers migrated and cleared small areas for crops. Over time the farms grew and industrial scale agriculture became the main reason behind the deforestation.

PHOTO: NASA/ASTER/ROBERT SIMMON



# Deforestation 2006

#### Rondônia, Brazil

▶ IN JUST SIX years, Brazil lost nearly 150,000km² of forest, an area larger than Greece. Even though the rate of deforestation has decreased, if it maintained its current level, 40 per cent of the Amazon Rainforest will have been destroyed by 2030.

PHOTO: NASA/ASTER/ROBERT SIMMON













# Gujarat Solar Park

### Gujarat, India

■ ASIA'S LARGEST SOLAR park is being constructed in western India. The park generates two-thirds of India's solar power and is estimated to save 8 million tonnes of carbon dioxide emissions per year. PHOTO: DIGITALGLOBE

### Solar power Near Seville, Spain

▼ THE PLANTA SOLAR 20 is the world's most powerful solar power tower. It consists of 1255 mirrors that reflect the solar radiation onto a receiver. This produces steam, which is then converted into electricity. PHOTO: NASA/GSFC/ASTER





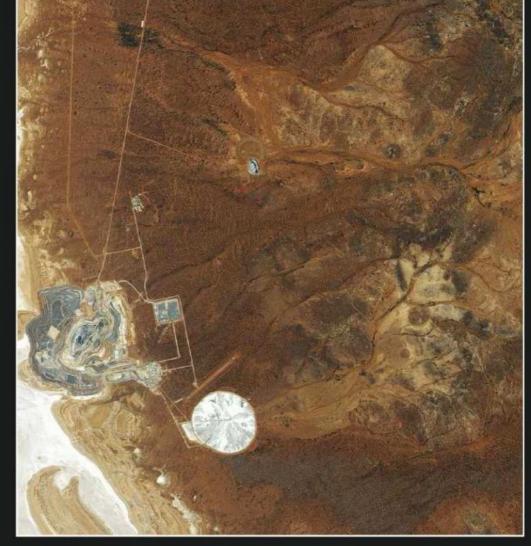


### Sunrise Dam Gold Mine

### Western Australia

▶ GOLD WAS DISCOVERED at Sunrise Dam in 1988 and mining began in 1995. Originally, it was an open pit mine, but in 2003 underground mining started as well. Its remote location means miners frequently have to be flown to and from the site.

PHOTO: NASA EO-1 TEAM/JESSE ALLEN



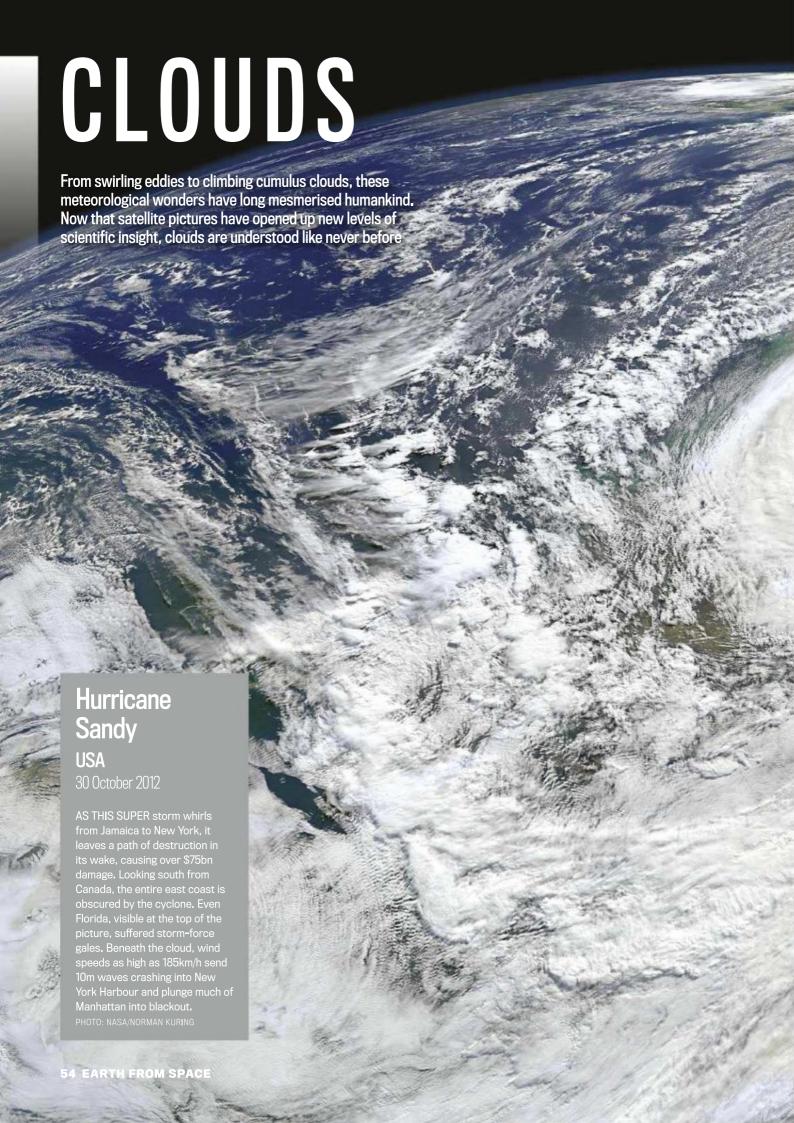
### Open pit mines Arizona, USA

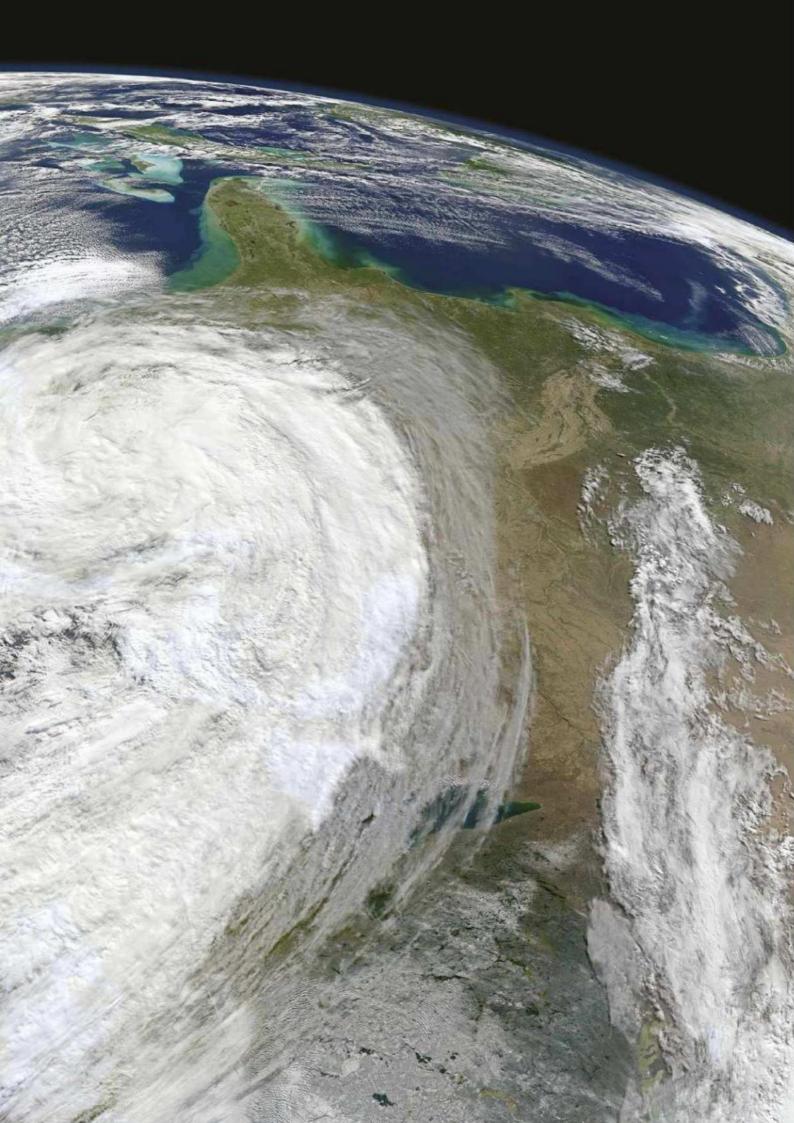
▼ ARIZONA IS THE United States' largest source of copper. As the mineral deposits are found near the surface, most of the mining is open pit. The Asarco Mission mine, on the left, processes over 48,000 tonnes of ore per day.

PHOTO: NASA/EXPEDITION 22 CREW









### Stratocumulus clouds

### Pacific Ocean

► THE SKY OVER the Pacific – the planet's largest ocean – plays host to many spectacular cloud displays. In the centre of this massive stratocumulus sheet lie two different phenomena. Von Karman vortices – spiralling eddies that form in a line – dance about just south of Guadalupe Island. In addition, two feint rainbow-like lines called 'glories' stretch across the cloud.

PHOTO: NASA/JEFF SCHMALTZ



# Ahead of the curve

#### Pacific Ocean

▶ AGAIN, ABOVE THE Pacific, a sheet of stratocumulus cloud hugs the Baja California Peninsula shoreline. But here, an arc over 1000km long slices through its centre. This curve emerged as the cloud bank parted over San Clemente Island, which lies beneath the thicker area of cloud in the top of the photo.

PHOTO: NASA/JEFF SCHMALTZ



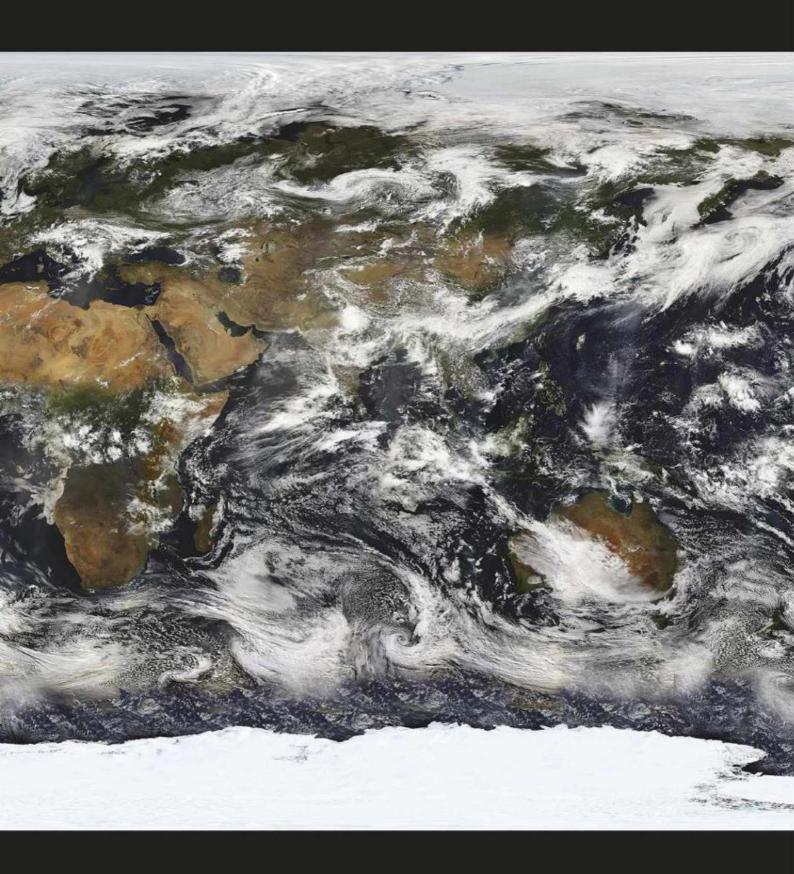




### State of flux

COMPOSED FROM SEVERAL different satellites' observations, this image shows that Earth's atmosphere is in constant circulation. Air rises at hot points around the equator and sinks where it cools. As land masses interrupt its flow and different weather fronts collide, clouds alter and intertwine in complex, ever-changing movement.

PHOTO: NASA/MARIT JENTOFT-NILSEN/ROBERT SIMMON







### Pressure point Tasmania, Australia

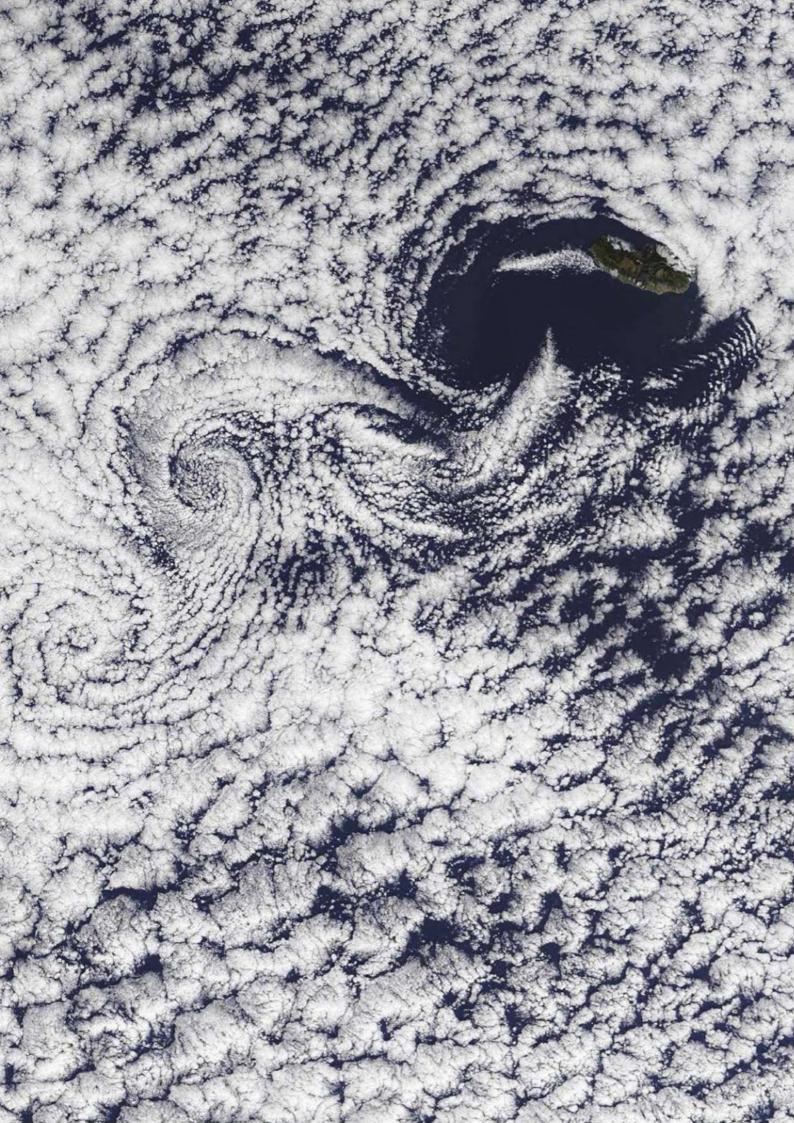
■ OFF THE WEST coast of Tasmania, a high-pressure system creates this spectacular chasm in the clouds. Over 1000km wide, this oval-shaped hole has been carved out as high pressure forces a pocket of air to sink down through the stratocumulus cloud blanket. PHOTO: NASA/JEFF SCHMALTZ

### High and dry Senegal and Mali

▼ A CUMULONIMBUS CLOUD towers over the African sky in this image taken from the International Space Station. As the massive cloud expands vertically, it meets a dry layer of the atmosphere that obstructs its rise. The still-growing cloud is forced to spread out, developing a distinct anvil shape. PHOTO: NASA/EXPEDITION 16 CREW







### On the horizon Pacific Ocean

► EVER WONDERED WHAT a sunset looks like from the International Space Station? As the Sun sinks, huge anviltopped thunderclouds cast long shadows over the Pacific and a golden pool of reflected sunlight appears in the sea.

PHOTO: NASA/EXPEDITION 7 CREW



▼ A PICTURESQUE ROW of storm clouds rain down over the Amazon, forming circular patterns. The cumulonimbus clouds' arc-like structures reveal that they're near the end of their cycles – soon their centres will collapse entirely.

PHOTO: NASA/GOES PROJECT









## CITIES In 1800, only three per cent of the world's inhabitants lived in a city. Today, there are more than 400 cities with a population over one million and half the global population is city-based San Francisco USA FOG IS A common sight for all San Franciscans, especially in summer. Cold air blows in from the Pacific Ocean, colliding with the warm Californian air and forming fog. San Francisco is the second most densely populated city in the USA, with 6632 people per km<sup>2</sup>. PHOTO: NASA EO-1 TEAM WWW.SCIENCEFOCUS.COM 67

### Venice

### Italy

▼ FAMED FOR ITS gondolas, the Grand Canal is the main thoroughfare in Venice, snaking through the centre of the city. The white dashes on this image are boats transporting people around. Founded in the fifth century, Venice is spread over 118 islands, linked by canals and more than 400 bridges.

PHOTO: NASA/ROBERT SIMMON

### Tokyo Japan

▶ ORIGINALLY A SMALL fishing village, Tokyo has grown into a metropolis with a population of 13.2 million. It increases by 2.5 million during the day as workers and students commute into the city. However, the population is expected to halve by 2100 as over 46 per cent of Tokyo's residents are past retirement age.

PHOTO: NASA/GSFC/ASTER













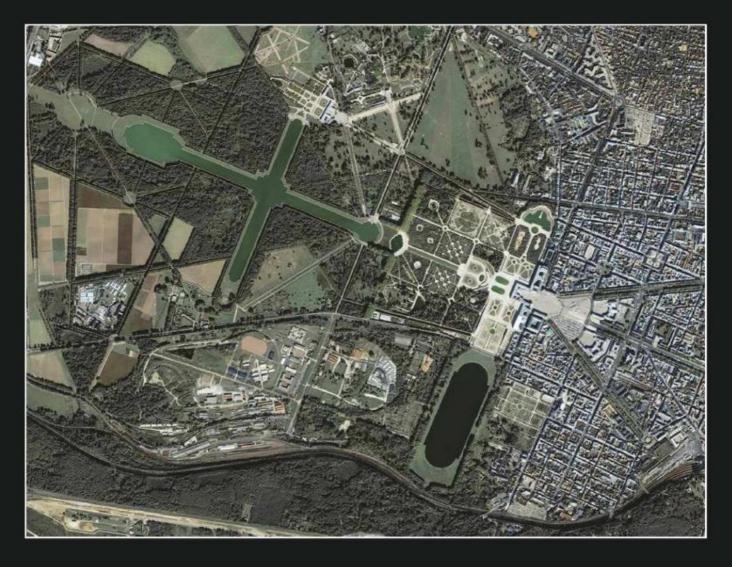
### Brasilia Brazil

■ BUILT IN 1956 and designed to look like an airplane, Brasilia is the largest city founded in the 20th Century. However, even though it's the capital, Brasilia is only the fourth largest city in Brazil. PHOTO: NASA EO-1 TEAM

### Versailles

### France

▼ WITH OVER 2000 rooms, the Palace of Versailles dominates the surrounding Parisian suburb. The gardens were designed in the 18th Century and completed before the French Revolution. PHOTO: DIGITALGLOBE/GETTY



### El Paso and Juárez USA and Mexico

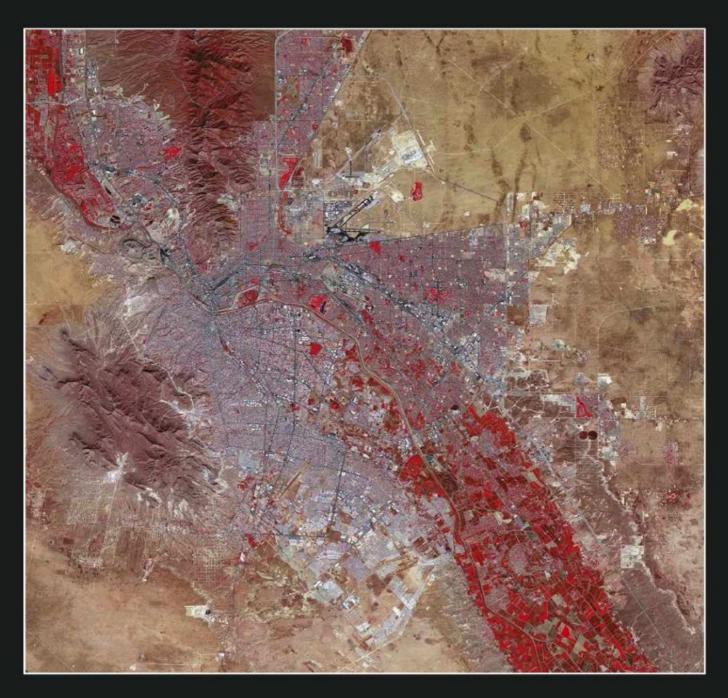
▼ FROM ABOVE, EL Paso and Juárez seem to be one city. Rio Grande, running diagonally across the image, is the border separating the USA and Mexico. In this false-colour image, vegetation is shown in red. The brightest shades are in El Paso, showing parks and gardens sustained by residents, in contrast with the barren land surrounding the cities. PHOTO: NASA/GSFC/ASTER

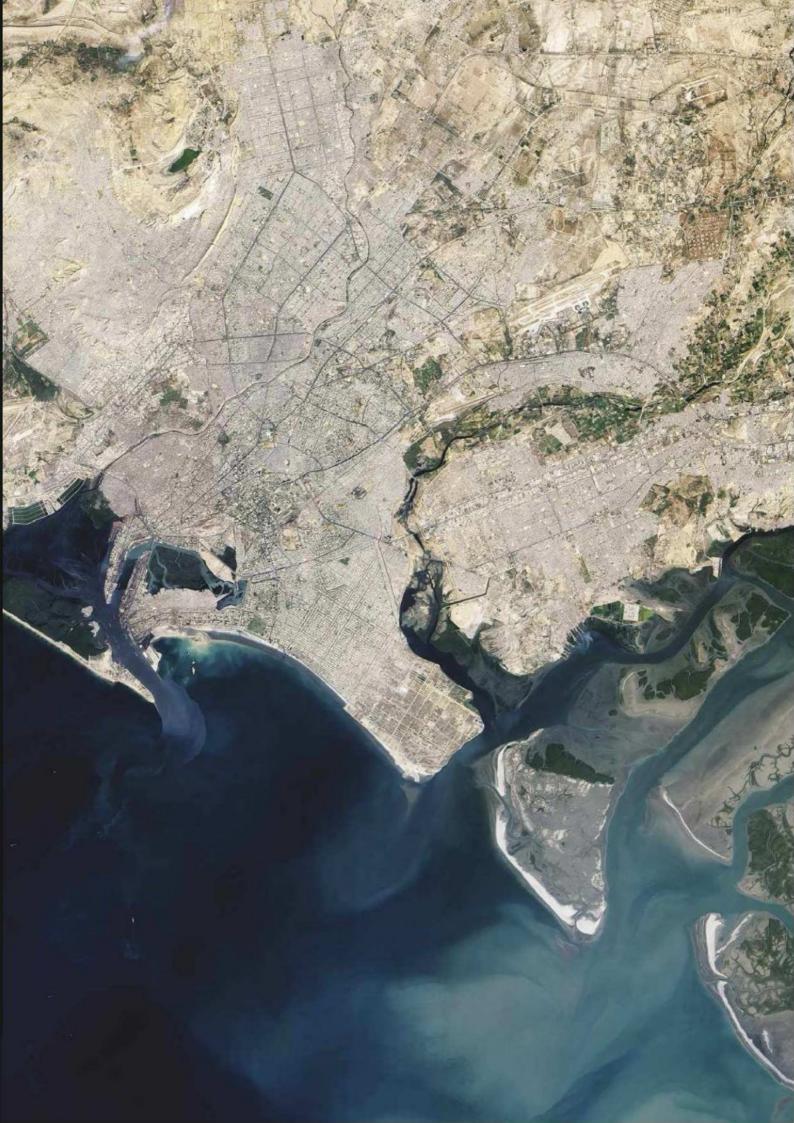
### Karachi

### **Pakistan**

▶ 'CITY OF LIGHTS', as it's also known, is the largest city in Pakistan. The oldest buildings are in the centre and a street grid system covers the rest of the city. Mangrove forests in the Arabian Sea bring some greenery to the otherwise heavily built up city.

PHOTO: NASA EO-1 TEAM





## THE HOT EARTH

Our planet runs on incredible amounts of heat – enough to constantly reshape its surface. From volcanoes powered by the Earth's molten-hot core, to the vast deserts dried out by the Sun, heat is as destructive as it is creative

### Sarychev Peak volcano

Kuril Islands, Russia

SARYCHEV PEAK ERUPTS, spewing massive plumes of ash into the sky. The smooth white ball is steam, created as water vapour in the air rapidly condenses above the rising hot ash. This phenomenon will last only a few moments, before the explosion engulfs the little round cloud.



## Grand Prismatic Spring

### Yellowstone Park, USA

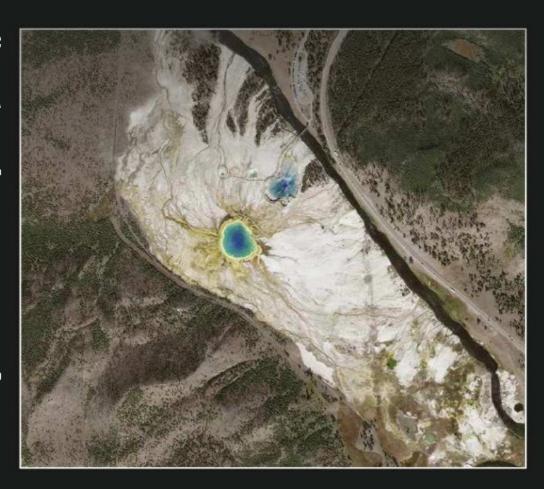
► THE THIRD LARGEST hot spring in the world, this geothermal pool can reach up to 87°C. Its vivid colours come from bacteria and algae that thrive in the warm, mineral-rich water.

PHOTO: DIGITALGLOBE/GETTY

## Valley of Geysers

### Kamchatka, Russia

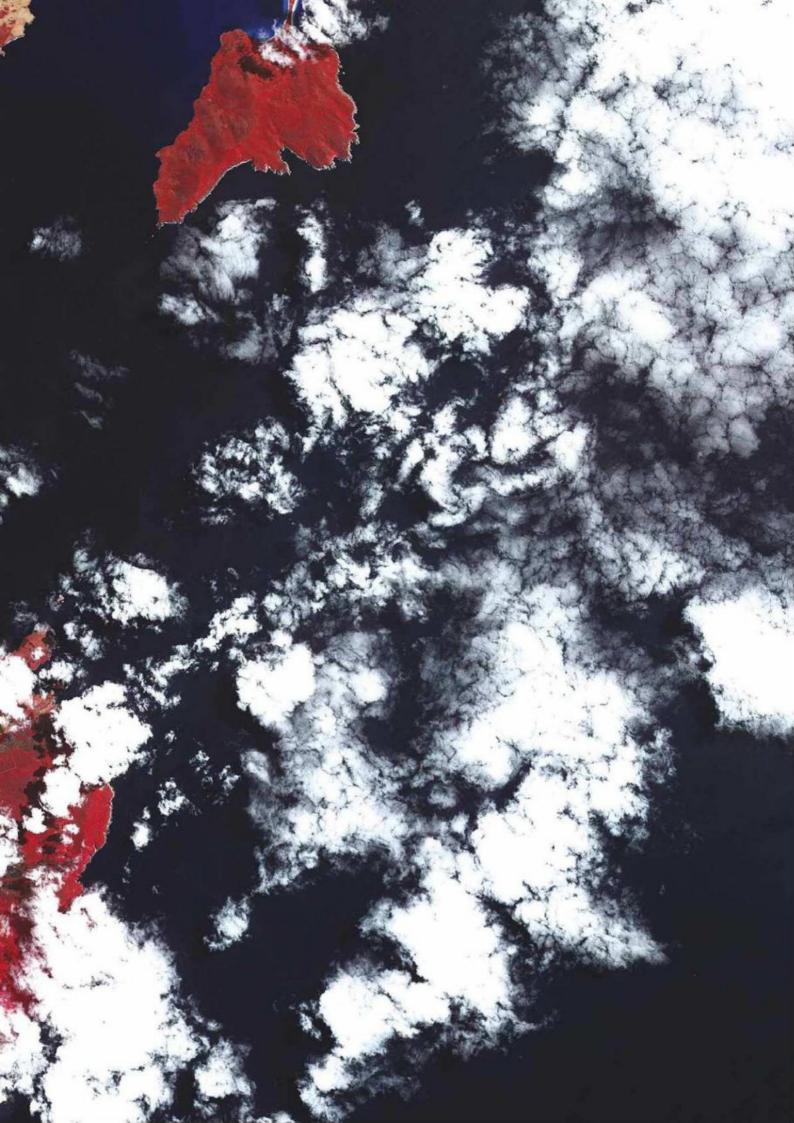
▼ DISCOVERED IN 1941, this remote basin contains around 90 geysers, as well as hot springs. Several years ago, a massive landslide inundated the valley, covering half of the geysers and causing a natural lake to form. PHOTO: DIGITALGLOBE















### Desert treasure Libya

■ RICH WITH MINERALS, these Saharan dust plumes will land in the Mediterranean - feeding phytoplankton at the start of the food chain - and across Europe. PHOTO: NASA/JEFF SCHMALTZ

### Catch the drift Iran and UAE

▼ TRAPPED IN THE Persian Gulf by a southwesterly wind, a thin veil of dust lingers over the Iranian shore, while a larger cloud escapes in the east. PHOTO: NASA/GSFC/JEFF SCHMALTZ







### **Mount Etna**

### Sicily, Italy

27 October 2002

► AFTER A SERIES of small earthquakes, Europe's most active volcano – located in the northeast corner of Sicily – erupts. Streams of lava flow down the summit's slopes, forest fires ignite and an ash cloud pours into the atmosphere, with volcanic matter falling as far away as Libya.

PHOTO: NASA/GSFC/JEFF SCHMALTZ

### Nabro Volcano

### Eritrea

30 June 2011

▼ SEVENTEEN DAYS INTO its eruption, Nabro's ash cloud clears to reveal hot lava running down the volcano's side. The molten rock oozes along the Ethiopian border, until it finally slows and cools when it hits level ground – over 7km west of the summit.

PHOTO: NASA/ROBERT SIMMON









# EARTH AT NIGHT

Cloaked in darkness, at night the planet is transformed into a mass of twinkling lights. The length of the night depends on location and season - the North and South Poles receive 24 hours of Sun in their summers but are blacked out in winter

### Southern Lights

**New Zealand** 

TAKEN BY CREW members on the International Space Station, this image shows the ethereal glow of the Aurora Australis. Aurorae occur when electrically charged particles from the Sun hit Earth's atmosphere. This aurora is green as a result of oxygen particles being struck. PHOTO: NASA/EXPEDITION 29





### Moscow Russia

■ PEERING OUT FROM behind a solar panel of the International Space Station is Europe's second largest city, Moscow, with a population of 11.5 million. On the horizon, daybreak meets the Aurora Borealis.

PHOTO: NASA/EXPEDITION 30

### **Phoenix** USA

▼ THE STREET GRID pattern of Phoenix is especially evident at night. The city is illuminated by more than 88,500 street lights at a cost of \$10m a year.

PHOTO: NASA/EXPEDITION 35











### **Darkness**

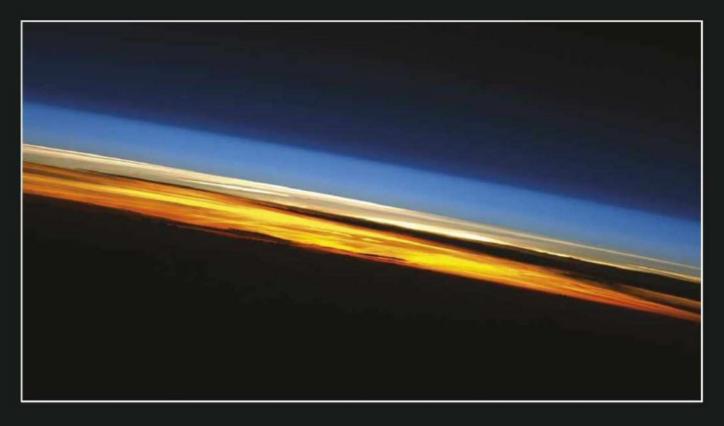
■ WHILE AMERICA IS waking, the rest of the world sleeps. The larger cities across Europe and Asia are instantly recognisable. With the exception of the Nile, which is densely populated, the rest of Africa has only a smattering of lights.

PHOTO: NASA/ROBERT SIMMON

### Sunset **Indian Ocean**

▼ THIS IMAGE HIGHLIGHTS the different layers of the Earth's atmosphere. The bright orange appears in Earth's troposphere, which extends up to 20km above the surface of the planet. Beyond that is the stratosphere and the blue layers above mark the transition through the upper atmosphere into the blackness of outer space.

PHOTO: NASA/EXPEDITION 23



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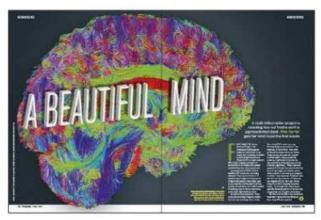
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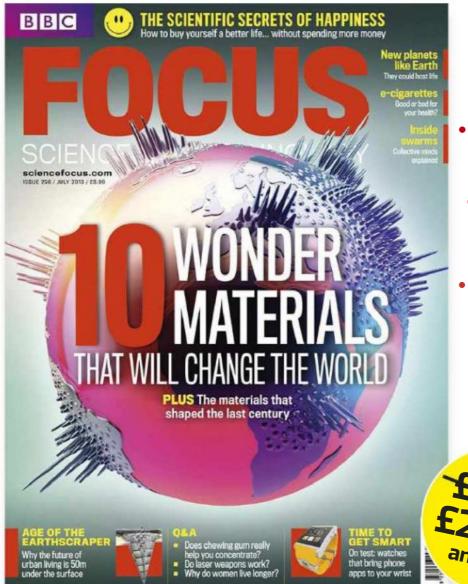
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AS THE MOON dips below the horizon, it appears to be floating in Earth's atmosphere. It is believed that when the Moon was formed it was 14,000km from Earth, However, it moves away from Earth at a rate of 3.8cm per year – roughly the same speed that fingernails grow. Today, our closest companion is over 400,000km from Earth and still moving.

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